Engine and Auxiliary Systems

Edited by
Prof. Dr. A.K.M. Mohiuddin

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Chapter 27

Numerical simulation of complex turbulent flows

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Introduction

Research and development work in engineering and science can be carried out using two basic methodologies, namely experimental testing or numerical simulation. Numerical simulation is fast emerging as a viable, relatively inexpensive option for experimental testing which can often involve very elaborate setups and prohibitively expensive equipment. As a result, the use of numerical simulations has steadily increased over the years and has accelerated significantly in recent years, catalyzed mainly by the development of efficient algorithms and fast computers that have significantly reduced the time taken for obtaining results. Numerical simulations generally involve solving single or multiple governing differential equations in a specified domain with appropriate boundary conditions. The level of complexity varies widely, ranging from the solution of simple ordinary differential equations in one dimension to highly complex scenarios where multiple, coupled partial differential equations are solved in complex geometries. One of the most challenging cases for numerical simulation is that of complex turbulent flows where the intricacy is not just limited to solving multiple, non-linear, coupled differential equations, but is compounded by the need to resolve a wide range of length scales in order to properly represent the physics of fluid turbulence. The aim of this chapter is therefore to introduce the governing equations and to discuss the fundamental nature of turbulence itself, in order to give the reader a preliminary insight into the challenges of carrying out a successful numerical simulation of turbulent flows.

Governing Equations

Numerical simulation of turbulent flows involves solving the Navier Stokes (NS) equations. The NS equations in conjunction with the continuity equation are widely believed to represent the turbulent transport of momentum and are given for incompressible fluids as